English Translation of Japanese Laid-Open Paten Application No. 10-28077

[Title of the Invention]

COMMUNICATION APPARATUS

[Name of Document] Abstract

[Problem]

It is an object of the present invention to provide a communication apparatus that can reduce interference between mobile stations in the cell of the mobile communication system, increase subscribers in the cell, and increase the frequency efficiency.

[Solving Means]

A communication apparatus comprising a function for diffusing the input data by a specified code, a transmitter equipped with a function for modulating and transmitting the diffused signal using one or more frequency channels, a receiver equipped with a function for demodulating each of frequency channel signals as well as equipped with a function for detecting correlation using the code equivalent to that of the transmitter, characterized in that the receiver has a function for judging the receiving time when the signals from one or more transmitters simultaneously, a function for judging the transmitting time of each transmitter so that the receiving time becomes constant, and a function for transmitting the transmission time from each transmitter to each transmitter, and the transmitter has a function for transmitting the

transmitted data in compliance with the transmission time transmitted from the receiver.

[Scope of Claim for a Patent]

[Claim 1]

A communication apparatus comprising a function for diffusing the input data by a specified code, a transmitter equipped with a function for modulating and transmitting the diffused signal using one or more frequency channels, a receiver equipped with a function for demodulating each of frequency channel signals as well as equipped with a function for detecting correlation using the code equivalent to that of the transmitter, characterized in that the receiver has a function for judging the receiving time when the signals from one or more transmitters simultaneously, a function for judging the transmitting time of each transmitter so that the receiving time becomes constant, and a function for transmitting the transmission time from each transmitter to each transmitter, and the transmitter has a function for transmitting the transmitted data in compliance with the transmission time transmitted from the receiver.

[Detailed Description of the Invention]

[0001]

[Technical Field Pertinent to the Invention]

The invention relates to a mobile communication system, and particularly to the configuration of communication apparatus.

[0002]

[Prior Art]

Conventionally, for this kind of system, there is a system that was disclosed in FIG. 1 of Page 835 of IEEEVTC95 of "Comparison of Different Detection Algorithms for OFDM-CDMA in Broadband Rayleigh Fading" by T. Muller et al. This system was configured to convert the input data by the Walsh matrix, then, convert by IFFT, and output. FIG. 1 shows the configuration of the modulator. FIG. 2 shows the configuration of the demodulator.

[0003]

[Problem to be Solved by the Invention]

However, in the conventional configuration, it is possible to diffuse the input data by the orthogonal code and transmit and simultaneously transmit from the transmitter of the base station of the mobile communication system to a plurality of mobile stations in the system and for each mobile station to synchronize and receive the data by the orthogonal code of each data with the orthogonal relationship maintained, but conversely, when the data to be transmitted from each mobile station is received by the base station, the received data at the base station cannot achieve synchronism of the received signal with the orthogonal relation of the orthogonal code maintained because the distance between the base station and each mobile station is different, respectively.

[0004]

[Means for Solving the Problems]

A communication apparatus comprising a function for

measuring the receiving time of the data diffused and transmitted by the orthogonal code from each mobile station at the base station in accord with each mobile station, a function for judging the deviation rate from the reference time in accord with each mobile station, and a function for compressing and encoding the advancing and delaying information of the time calculated to achieve synchronism of orthogonal codes of the received signal from each mobile station at the base station, and further comprising each mobile station equipped with a function for adjusting and transmitting the time of the data diffused and transmitted by the orthogonal signal to match the advancing and delaying information of the received time.

[0005]

[Mode for Carrying Out the Invention]

The mode for carrying out the invention (how to practice the invention) which is assumed best is briefly explained with its working effects shown in conformity to figures.

[0006]

In the configuration of the transmitter on the mobile station side of the present invention, the input data is decomposed into a plurality of parallel data through the serial-parallel converter, each data is diffused using characteristic orthogonal codes, and the diffused data is modulated by the carrier frequency in the orthogonal relation, and is transmitted. Consequently, the data speed of one channel is reduced by the number of channels.

[0007]

For the orthogonal code, the Walsh code and other codes are used. The carrier frequency in the orthogonal relation is demodulated by reverse-discrete-Fourier converting the signals diffused by a plurality of orthogonal codes, and parallel-serial converting the outputs.

[0008]

In the configuration of the receiver of the base station, the data transmitted from a plurality of mobile stations and diffused by characteristic orthogonal codes are simultaneously received. In conformity to the receiving timing of the signal of each mobile station, each signal is discrete-Fourier-converted and the correlation is achieved by the characteristic orthogonal code of each mobile station. The correlation output is parallel-serial-converted to judge the data. Using this judged data, by the delay time signal predictor, the delay time is calculated. The delay time is the deviation time from the nearly average timing of the receiving timing of received signals from all the mobile stations.

[0009]

The delay time is digital-coded and transmitted from the transmitter of base station to the receiver of mobile station. The mobile station receives the delay time, decides the transmission timing in compliance with the time corresponding to the time, and transmits the transmission signal.

[Example]

[0010]

Referring now to drawings, specific working examples of

the present invention will be described in detail as follows.

[0011]

First Example

1. Description on the configuration

FIG. 3 is a configuration diagram of the transmitter on the mobile station side showing the first example of the present invention, and the input data 301 is a serial-parallel converter 302 and is converted into the 1-to-N parallel data. The speed of the data of each channel converted by the serial-parallel converter 302 is 1/N the input data speed.

[0012]

The converted data becomes the diffused signal using the Walsh code 303, the orthogonal code, by the diffuser 304. To the diffused signal of the channel, the pilot signal 314 is added. The pilot signal may be added to a plurality of channels.

[0013]

The diffused signal is outputted through the discrete-reverse-Fourier-conversion 305. The discrete Fourier converted signal converts each channel into continuous data by the switching unit 306 and outputs. The outputting timing is carried out in conformity to the data received from the receiver 307. The signal outputted in conformity to the transmission timing is outputted via the D/A converter 309. The output signal is modulated by the carrier frequency and transmitted.

[0014]

FIG. 4 is a configuration of the receiver on the base

station side showing the first example of the present invention, and the received signal 401 is demodulated by the receiving carrier frequency 402. The demodulated signal is converted into the digital signal by the A/D converter 403 and after sample-holding, it is converted into the parallel signal of N channels by the discrete Fourier conversion 404. With respect to the channel signal with the pilot signal added on the transmission side of FIG. 3, the correlation to the pilot signal 415 is calculated. The correlation calculation output is inputted to the propagation path estimating and timing extraction circuit 414.

[0015]

On the other hand, each channel signal achieves the correlation by the orthogonal code 405 same as that on the transmitting side. The output becomes the serial data via the parallel-serial converter 407. On this data, noises corresponding to the time difference with the received data from the surrounding mobile stations are superimposed. This data is judged by the judge device 409. Using the noise signal and the delay time control signal predictor 411, the delay time is predicted. The predicted delay time difference is coded and is transmitted from the transmitter of base station to each mobile station.

[0016]

This signal becomes the input signal to the receiver 307 shown in FIG. 3 above and the timing of the transmitted signal of each mobile station is adjusted.

[0017]

2. Description on operation

FIG. 6 shows the time chart in the configuration of the modulator of FIG. 3. The modulator is located on the mobile station side. Description will be made on the modulator of one mobile station. Let "d" denotes the data speed of the input data (a). The data is converted into the parallel data (b) by the serial-parallel converter of N channels. The data speed per each channel becomes d/N of one Nth.

[0018]

The data of each channel is made into M-fold diffused signal (d) by the Walsh code (c), a kind of orthogonal code assigned to each user. M and N may be the same. FIG. 6 shows the case when N and M are equal for convenience sake. Consequently, the speed of the channel signal after diffusion becomes "d." Now, the Walsh code assigned to one mobile station is one kind.

[0019]

Of these, to at least one channel signal, the pilot signal (e) is added. To which channel the plot signal is added should be decided in advance. The pilot signal chooses the Walsh code which has the orthogonal relation with the orthogonal code assigned to each user. Here, no additive result with the pilot signal is shown.

[0020]

Each diffused channel signal is discrete-reverse-Fourier-converted (f). Here, the results of the actual part

and imaginary part of channel 1 and channel 2 are shown. The results of channel 3 and channel 4 are omitted.

[0021]

The discrete Fourier converted output (g) is made into a continuous data using the switching unit. The speed of the switching unit is d/N in this example. The timing of transmitting the switching unit output is decided in conformity to the transmission timing signal of the delay time control signal obtained form the receiver. With the transmission timing adjusted by the delay time control, the output is allowed to pass the D/A converter, modulated by the transmission carrier frequency, and transmitted.

[0022]

The same as the results of FIG. 6 is obtained for the time chart in the configuration of the modulator of FIG. 4. The modulator is located at the base station and simultaneously receives signals from a plurality of mobile stations. The receiving timing from each mobile station varies to the relative distance between the base station and the mobile station.

[0023]

The operation is described with respect to the receiving signal from one mobile station. The receiving signal is demodulated (g) by a mixer. The demodulated signal is converted (d) into each channel signal by the discrete Fourier conversion. At the converter, to the channel with the pilot channel added, correlation to the pilot signal (e) is calculated and the propagation path of the radio circuit is estimated, and at the

same time, the receiving timing of the pilot signal is decided.

[0024]

Each channel signal carries out correlation calculation using the Walsh code (c) specified by the modulator. For the correlation timing of the correlation calculation, the receiving timing found by the correlation calculation with the pilot signal is used. Each channel data (b) is parallel-serial converted into the serial data (a). Based on the serial data, the data judgment is performed and the received data is obtained.

[0025]

Next discussion will be made on the delay time control section. Because the demodulator simultaneously receives signals from each mobile station, deviation is generated in the receiving timing according to the relative distance between each mobile station and the base station. This deviation is added to the output of the parallel-serial converter of FIG. 4 as interference noise.

[0026]

In FIG. 4, as one example of the method for evaluating this noise volume, the noise volume is found from the difference between the output of the parallel-serial converter and the output of the data judgment. The signal output of the difference is shown by the following equation.

[Eq. 1]

where, uk(t) denotes the judgment data.

[0027]

Let Rk(t) denote the output of the parallel-serial converter. This signal is inputted to the delay time control signal predictor 411. At the delay time control signal predictor, the mean square of the error signal is found.

[Eq. 2]

The delay time Tdk(v+1) is updated by the use of the following equation.

[Eq. 3]

where $\Delta Td$ denotes the updated volume of delay time. v denotes the suffix indicating the present delay time. v+1 denotes the suffix that determines the updated volume of the delay time at the following time.

[0028]

In actuality, when the delay time is transmitted as it is, by the increase of the information volume, in the delay time control signal encoder, the information volume is compressed to transmit to each mobile station, such that the delay time is advanced or delayed in a specified time, and nothing is done. This coding can be freely chosen by the system configuration.

[0029]

Each mobile station shown in FIG. 3 demodulates this information by the receiver, and determines on the basis of the predetermined delay timing width 308, adjusts the transmission timing from each mobile station, and transmits the data.

[0030]

In the description made so far, the operation was explained on the basis of the down-hill method for the delay time control method, but the same operation can be obtained by the use of equalizer using the method of least squares.

[0031]

In the description made so far, each channel controls the delay time to automatically minimize the interference, but it is possible to control the delay time by setting common reference time for all the channels, inputting the time to the delay time control predictor 411 of FIG. 4 of each channel, and allowing the delay time control signal encoder 412 to find the delay time signal to match the time.

[0032]

In the description made so far, nothing is described on the initial transmission timing of each mobile station. It is also possible to carry out the delayed time control mentioned above after the mobile station transmits the data at the timing when the station received the data.

[0033]

It is possible to control the delayed time even if the relative distance between each mobile station and the base station greatly deviates by combining with the system that automatically minimizes the interference signal.

[0034]

In addition, a guard interval may be used for removing interference. This is not an essential condition in the present

invention.

[0035]

In the description made so far, discussion has been made on the communication apparatus using the delay time control for the multi-carrier system of spectrum-diffusing the data, but this system can be applied to the spectrum-diffusion apparatus itself.

[0036]

3. Description on the effects

Configuring the communication apparatus as in the case of the first working example when the data is transmitted from mobile station to base station can achieve synchronism of orthogonal codes used at each mobile station as data diffusing signals irrespective of the relative distance between each mobile station and the base station. By this, a multi-carrier communication apparatus for diffusing the data with excellent error characteristics can be configured.

[0037]

Description on utilization mode

In the present working example, description was made by the example in which the communication apparatus is used in the radio circuit, but the present invention can be applied to optical communication apparatus using optical fibers with base band signals modulated by light in place of radio modulated signals. Furthermore, it is possible to apply to wire communication apparatus using MODEM analog modulation used for wire circuits in place of radio modulation signals.

[0038]

Modulation was carried out by the carrier frequency, but the present invention can be applied to underwater communication apparatus by using the vibrator.

[0039]

[Effect of the Invention]

Because the present invention is configured as described above, interference of the transmitted signal from each mobile station received at the base station can be reduced and a communication apparatus with excellent noise-resistant characteristics can be achieved.

[Brief Description of the Drawings]

FIG. 1 is an explanatory drawing showing the configuration of a conventional multi-carrier modulator;

FIG. 2 is an explanatory drawing showing the configuration of a conventional multi-carrier demodulator;

FIG. 3 is an explanatory drawing showing the configuration of multi-carrier modulator on the mobile station side of the first working example;

FIG. 4 is an explanatory drawing showing the configuration of multi-carrier demodulator on the base station side of the first working example;

FIG. 5 is an explanatory drawing showing the configuration of multi-carrier demodulator on the base station side of the second working example; and

FIG. 6 is a time chart of a transmitter of the first working example.

FIG. 1

101 INPUT DATA

102 ORTHOGONAL SIGNAL

103 IFFT

104 GUARD INTERVAL ADDED 104

105 TRANSMITTED SIGNAL

FIG. 2

201 RECEIVED SIGNAL

202 FFT

203 EQUALIZER

204 PROPAGATION PATH ESTIMATOR

205 ORTHOGONAL SIGNAL

206 INTEGRATOR

207 DEMODULATED SIGNAL

FIG. 3

301 INPUT DATA

302 FFT

303 WALSH CODE

304 DIFFUSER

305 DISCRETE REVERSE FOURIER CONVERSION

306 SWITCHING UNIT

307 RECEIVER

308 DELAY TIME WIDTH

309 D/A

310 DELAY TIME CONTROL

311 TRANSMISSION CARRIER FREQUENCY

312 DEMODULATOR 312

313 TRANSMITTED SIGNAL

FIG. 4

401 RECEIVED SIGNAL

402 RECEIVED CARRIER FREQUENCY

403 A/D

404 DISCRETE FOURIER CONVERSION

405 WALSH CODE

406 CORRELATION DEVICE

407 PARALLEL SERIAL CONVERTER

408 PARALLEL SERIAL CONVERTER OUTPUT

409 DATA JUDGE DEVICE

410 RECEIVED DATA

411 DELAY TIME CONTROL SIGNAL PREDICTOR

412 DELAY TIME CONTROL SIGNAL ENCODER

413 TRANSMITTER

414 PROPAGATION PATH ESTIMATING AND TIMING EXTRACTION CIRCUIT

414 415

PILOT SIGNAL 415

FIG. 5

501 RECEIVED SIGNAL

502 RECEIVED CARRIER FREQUENCY

503 A/D

504 DISCRETE FOURIER CONVERSION

505 WALSH CODE 505

506 CORRELATION DEVICE

507 PARALLEL SERIAL CONVERTER

508 PARALLEL SERIAL CONVERTER OUTPUT

509 DATA JUDGE DEVICE

510 RECEIVED DATA

511 TRANSMITTER

512 DELAY TIME CONTROL SIGNAL ENCODER 512

FIG. 6

(A) INPUT DATA

(B) SERIAL PARALLEL CONVERTED OUTPUT

CHANNEL 1

CHANNEL 2

CHANNEL 3

CHANNEL 4

(C) WALSH

(D) PARALLEL SERIAL CONVERTER OUTPUT

CHANNEL 1

CHANNEL 2

CHANNEL 3

CHANNEL 4

(E) PILOT SIGNAL

(F) IFFT OUTPUT

CHANNEL 1

REAL PART

IMAGINARY PART

CHANNEL 2

REAL PART

IMAGINARY PART

(G) COMPOSITE OUTPUT

REAL PART

IMAGINARY PART